Public Health England

Health Risk Assessment of Air Quality Monitoring Results: Southall Waterside Development

Non-Technical Summary

Public Health England (PHE) has been asked by Ealing Council to review air quality monitoring data for the former Southall Gasworks site, known as the Southall Waterside Development following public concerns regarding the ongoing construction works at the site. Air quality monitoring has been carried out by Atkins (an environmental consultancy), on behalf of Berkley West Thames (the developer). Monitoring for total volatile organic compounds (VOC) in air started in January 2017 and enhanced VOC monitoring has been in place since June 2018.

Findings

- The data provided to PHE by Ealing Council has been compared to available health based air quality guidelines and standards or assessment levels. Where the concentrations in air are shown to be lower than appropriate health based standards or guidelines, it may be assessed that the risk to health is minimal.

- On the basis of the available monitoring data, the majority of the identified chemicals were lower than the relevant air quality guidelines or standards, with the exception of benzene, trichloroethylene, trimethylbenzene and 4-isopropyltoluene, which were intermittently above the guideline values whilst naphthalene levels were regularly above the guideline values.

- The exceedances have been for shorter periods compared with the health based guidelines which are based on annual average concentrations and are set to be protective over a lifetime; therefore, exceedances for part of the lifetime would not automatically result in an increased risk to health.

- The exceedances have also remained below levels likely to cause acute or short term health effects. Furthermore, it should be noted that monitoring stations are positioned on the site boundary and the concentrations of the compounds in air will have diluted further before reaching the surrounding population, reducing the potential risk.

- The results obtained from the air quality monitoring indicate there is unlikely to be a direct toxicological risk to the health of the nearby population from the levels of VOCs detected.

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- It is noted that there is a continued decrease in VOC concentrations following closure of the soil treatment hospital at the beginning of April 2019. This continuing improvement is welcome, however it is recommended that mitigation measures and monitoring is continued, so that the potential health risk can be minimised and kept under review, in light of any further works on and in proximity to the site.

- The public's concerns in relation to odours are acknowledged. It is important to make a distinction between concerns about odour and any toxicological effect from exposure to airborne chemicals. The human nose is very sensitive to odours, and substances that are perceived as odorous are commonly present at levels below which there is a direct toxicological effect. Odours can cause nuisance amongst the population possibly leading to stress and anxiety. Some people may experience symptoms such as nausea, headaches or dizziness, as a reaction to odours even when the substances that cause those smells are themselves not harmful to health.

- The monitoring data has identified that some chemicals have been recorded above odour thresholds (the point at which most people can detect the smell) and that the surrounding population may have been subject to some odours as part of the ongoing construction works. One of these chemicals is naphthalene, which has a distinctive odour of mothballs, and it is possible that the surrounding population may have experienced some odours as part of the ongoing construction works.

- PHE has previously completed three interim health risk assessments and this final health risk assessment reports on all monitoring data to January 2020. PHE recommends that measures continue to be taken by Ealing Council / Property Developer to reduce off-site odours from the construction site, as it is acknowledged that odours can affect an individual's wellbeing.

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Background and Scope

Concerns have been raised by the community about the redevelopment of a site known as the Southall Waterside Development, located at the former Southall Gasworks. The community are concerned about redevelopment activities causing poor air quality or nuisance and adversely impacting the community's health. PHE have been asked by Ealing Council to review air quality monitoring data for the site in order to undertake an independent public health risk assessment.

Atkins (an environmental consultancy) have been appointed by Berkley West Thames (the developer) to carry out air quality monitoring for the site and have provided the following reports for PHE to review:

- Southall Waterside, Tenax monitoring analysis, no.A720-E05-SW-XX-ATK-EN-TN-0001, version P2.
- Southall Waterside, Response to PHE request for further information, no.A720-E05-SW-XX-ATK-EN-TN-0005, version P2.
- Southall Waterside, Additional information request from PHE, no.A720-E05-SW-XX-ATK-EN-TN-0006, version P3.
- Southall Waterside, Update report for PHE, no.A720-E05-SW-XX-ATK-EN-TN-0007, version P4.
- Southall Waterside, Update for PHE – June 2019, no.A720-E05-SW-XX-ATK-EN-TN-0008, version P4.
- Southall Waterside, Update for PHE – Results to end September 2019, no.A720-E05-SW-XX-ATK-EN-TN-0009, version P3.
- Southall Waterside, Update for PHE – Results to end 2019, no.A720-E05-SW-XX-ATK-EN-TN-0011, version P3.

PHE have previously completed three interim risk assessments, the first of which was based on air quality monitoring undertaken between 1st June and 25th September 2018, the second was based on air quality monitoring undertaken between 25th September and 12th December 2018 and the third was based on air quality monitoring undertaken between 12th December 2018 and 10th May 2019. This report and risk assessment has been updated following receipt of additional air quality monitoring data undertaken between 10th May 2019 and 6th January 2020.

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Methodology: Air quality standards and assessment levels

The data provided to PHE has been compared to available health based air quality guidelines and standards or assessment levels for the detected chemicals. There are a variety of health based standards and assessment levels that have been developed by a number of organisations. The hierarchy of standards and assessment levels used for this assessment is shown below:

- UK and European Air Quality Standards[1].
- World Health Organisation (WHO) air quality guidelines[2,3].
- Other UK air quality assessment levels[4,5,6].
- National air quality assessment levels (other than UK, and referenced where used).

Where two or more UK or National (other than UK) air quality assessment levels are identified, the lowest value has been applied.

The WHO has developed air quality guideline values for key air pollutants both outdoors and inside buildings. For non-cancer causing compounds, exposure to levels below the guideline value, for a given period of time, would not be expected to cause a significant health risk. For relevant cancer-causing compounds guidelines have been developed corresponding with different levels of lifetime cancer risk (i.e. for benzene and trichloroethylene concentrations associated with between a 1 in 10,000 and 1,000,000 excess lifetime risk are given).

The US Agency for Toxic Substances Disease Registry has derived minimal risk levels (MRL) for some chemicals. An MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse non-cancer health effects over a specified duration of exposure. MRLs are derived for acute (1-14 days), intermediate (>14-364 days), and chronic (365 days and longer) exposure durations[7].

Where available, authoritative guidance on odour thresholds have been presented. These are the concentrations at which most people can detect a smell. It is important to make a distinction between concerns about odour and any toxicological effect from exposure to airborne chemicals. The human nose is very sensitive to odours, and

[1] UK Air Quality Objectives
https://uk-air.defra.gov.uk/assets/documents/Air_Quality_Objectives_Update.pdf
[2] World Health Organization, Air Quality Guidelines for Europe, Second Edition, 2000
http://www.euro.who.int/__data/assets/pdf_file/0005/74732/E71922.pdf
[3] WHO (2010) WHO Guidelines for Indoor Air Quality: Selected Pollutants
http://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf?ua=1
[4] Public Health England, Indoor Air Quality Guidelines for selected Volatile Organic Compounds (VOCs) in the UK, September 2019
[5] Environmental Assessment Levels
https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air-emissions
[6] EH40/2005 Workplace exposure limits, Fourth Edition 2020
[7] https://www.atsdr.cdc.gov/mrls/index.asp

substances that are perceived as odorous are commonly present at levels below which there is a direct toxicological effect.

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Methodology: Monitoring Locations and Chemical Analysis

Air quality monitoring at fixed sites around the site perimeter was established from January 2017, initially with testing for total volatile organic compounds (photoionization detector (PID) testing method), which was later supplemented with enhanced (Tenax testing method) sampling from June 2018. Tenax tubes were positioned at monitoring locations for weekly periods (therefore indicating weekly concentration), prior to be sent to the testing laboratory by the developer.

The following observations are made about the changes in monitoring locations during the reporting period:

- The Tenax sampling initially comprised 10 monitoring locations, which on the 18th September 2018 (week 16) was increased to comprise 21 monitoring locations. Atkins reported the reason for this increase was to provide additional information on the rate of change in concentration with increasing distance from the soil hospital and excavation areas, as well as to capture information in new areas where works were expected to take place.
- The monitoring undertaken from week 33 (24th January 2019) has been undertaken intermittently at additional locations (maximum of 25 locations monitored), which has included three off-site monitoring locations from week 42).
- From week 52 (6th June 2019), monitoring was commenced at the site entrance to the south-west (Air 23). The rationale for this additional location is unspecified. From week 52, a maximum of 26 monitoring locations were reported on a weekly basis.

The fixed monitoring locations are detailed in Figure 1 below.

Figure 1 – Position of fixed-site monitoring locations

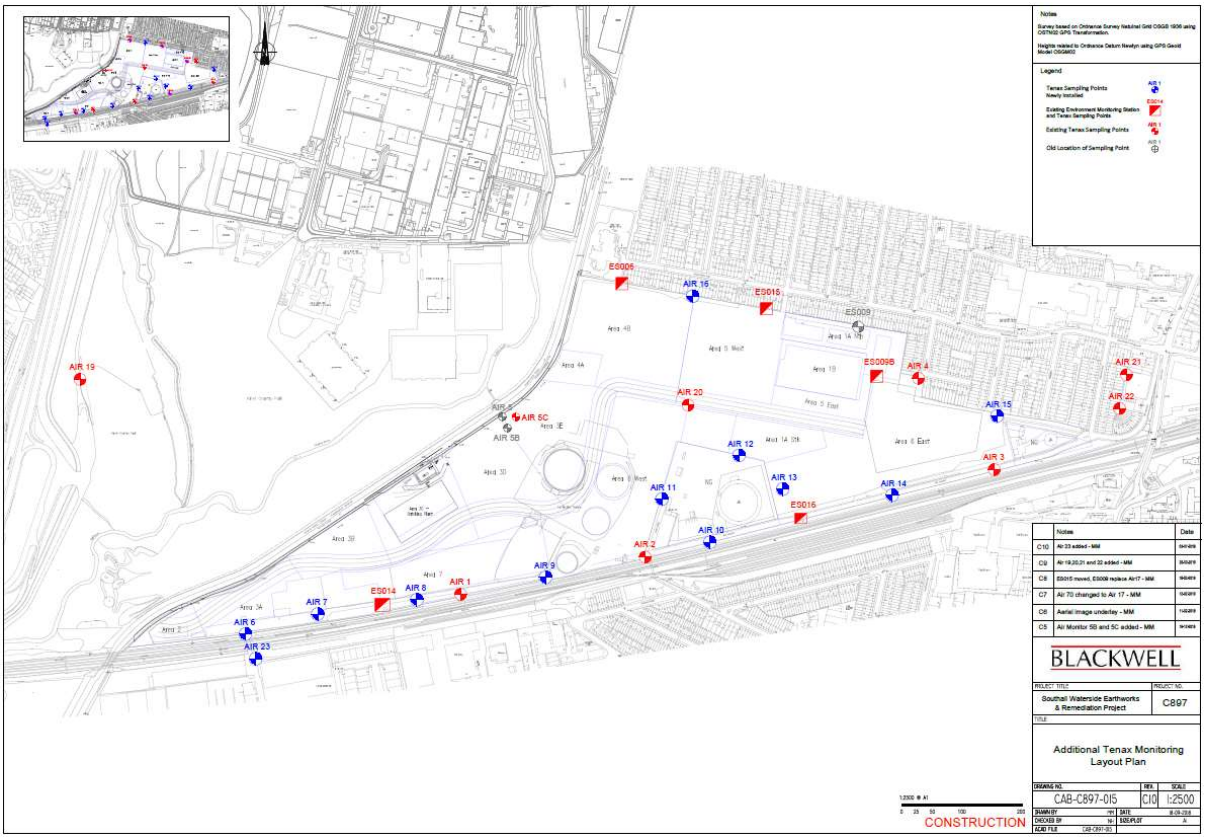

Figure provided by Atkins.

The developer has provided monitoring data from between 1st June 2018 and 6th January 2020 (covering a 81 week monitoring period). The monitoring has included testing of groups of chemicals called aliphatic and aromatic hydrocarbons (banding C5-16) and select semi-volatile and volatile organic compounds (SVOC and VOC). These chemicals are commonly found on former gas works sites and are commonly associated with fuels (i.e. petrol and diesel). Some of these chemicals have odorant properties, i.e. have a smell, which may be considered unpleasant, whereas other chemicals do not smell.

The following observations are made on the monitoring locations, methods and chemical testing undertaken:

- Monitoring points are positioned on all boundaries of the site and as such, would allow assessment of air quality concentrations should the wind direction change.
- Monitoring points are positioned between the site and the community including sensitive locations such as Beaconsfield Primary School, Blair Peach Primary School, Guru Nanak Sikh Academy and residential properties to the north, east and south. This would allow assessment of levels of chemicals which would give a worst case estimate of exposure for the surrounding population.
- The site has historically been used for a variety of industrial land uses including the Southall Gas Works, all of which have the potential to impact the type and

concentration of chemicals present in soil and air as part of the remediation works. The air quality monitoring aims to assess or capture the likely chemicals present on such sites.

- From week 42, additional off-site monitoring locations have been used, which are positioned approximately 400m west within Minet Country Park (Air 19) and approximately 150m east in the vicinity of Randolph Road (Air 21 and Air 22). From week 52, an additional monitoring location (Air 23) was positioned close to the south-western boundary of the site. It is noted that the monitoring at these locations commenced at the end of the soil treatment hospital works.

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Air Quality Monitoring Results and Discussion

For each of the chemicals detected, PHE has calculated the average and maximum values from the data for comparison against available air quality standards or guidance values. Average concentrations for specific areas of the site have been calculated to support the assessment as detailed below:

- It is noted that the most likely source of chemicals was the remediation work in the soil treatment hospital positioned in the south-western portion of the site. The calculation of a site-wide average value includes results from all monitoring results (i.e. from the soil hospital in the south-western portion of the site and in the north-eastern portion of the site where chemical concentrations would likely decrease as they have been diluted in air). Residents present to the south of the site are in closer proximity to the soil hospital, therefore average chemical concentrations from the five monitoring stations closest to the soil hospital (monitor Air 1, Air 7, Air 8, Air 9 and ES14) have been calculated for a precautionary assessment. It is important to note that there would be some degree of dilution of chemicals in air between the soil hospital or site boundary and the surrounding population which would make these an over-estimate of potential exposure to the residents. It is acknowledged that works at the soil treatment hospital have ceased; however, it is understood that further works have been undertaken at this location involving the excavation and removal of the soil hospital from the site. Average concentrations presented have been calculated based on the total monitoring period (weeks 1-81) as opposed to when the soil treatment hospital was in operation. This was calculated so that concentrations can be updated as further monitoring data became available, noting that further works have been completed in this area and to allow comparison against the respective air quality guideline values.
- The rest of the surrounding population live to the north and east of the site, and there would have been dilution of the chemicals in air as they moved from the source (the soil hospital) to residential, amenity and educational areas in the vicinity of the site in those directions. Therefore, average on-site concentrations excluding the 5 monitoring stations closest to the soil hospital have been calculated to provide a more representative, but still precautionary, exposure estimate for the majority of the surrounding population.
- Average concentrations have been calculated for the site following closure of the soil treatment hospital in week 43 (4th April 2019) for all monitoring locations to identify if there has been a decrease in exposure following cessation of works in this area.
- Average concentrations have been calculated for off-site monitoring locations (Air 19, Air 21, Air 22 and Air 23) to assess the potential for dilution of compounds in the air from the site boundary. Monitoring commenced at Air 19, Air 21 and Air 22 in week 42 (one week prior to the closure of the soil treatment hospital) and monitoring commenced at Air 23 in week 52.

For clarity, Table 1 below details which monitoring locations have been used to calculate each reported concentration.

Table 1 – Monitoring locations used to calculate reported concentrations

Reported concentration	Monitoring locations used to calculate value
Range of recorded weekly concentrations	Range of concentrations recorded across all on and off-site monitoring locations
Average on-site concentration recorded	All on-site monitoring locations excluding off-site locations (Air 19, Air 21, Air 22 and Air 23) (Weeks 1-81)
Average on-site concentration recorded near the soil hospital	All on-site monitoring locations near the soil hospital (Air 1, Air 7, Air 8, Air 9 and ES14) (Weeks 1-81)
Average on-site concentration recorded excluding the soil hospital	All on-site monitoring locations excluding those near the soil hospital (Air 1, Air 7, Air 8, Air 9 and ES14) and those off-site (Air 19, Air 21, Air 22 and Air 23) (Weeks 1-81)
Average on-site concentration following closure of the soil hospital	All on-site monitoring locations (excluding off-site locations: Air 19, Air 21, Air 22 and Air 23) (Weeks 43-81)
Average concentrations recorded in off-site monitoring locations	Air 19, Air 21, Air 22 and Air 23 (Week 42-81). Note monitoring at these locations commenced in Week 42, except for Air 23 which commenced in Week 52

By calculating the average values over the 81 week enhanced monitoring period, the chemical concentrations recorded can be checked against air quality standards and guidance values, as such values are based on the chemical concentrations across an appropriate time period (often an annual average is used). No assessment has been undertaken where a chemical has recorded concentrations below laboratory limits of detection.

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Chemicals Concentrations Recorded Above Assessment Criteria

The majority of the identified chemicals were lower than the relevant air quality guidelines or standards, with the exception of benzene, naphthalene, trichloroethylene, 4-isopropyltoluene and trimethylbenzene, all of which recorded peak or average concentrations above their respective air quality standards. The following section presents a summary of the recorded concentrations of each of these compounds, compared with available health-based standards or assessment levels and discusses the findings. Not all chemicals have UK air quality standards, assessment levels or WHO guidelines. Where this is the case, if available, relevant alternative guidelines have been used for assessment of the reported concentrations of those chemicals in the air.

Benzene

Table 2 – Recorded Benzene Concentrations and Air Quality Assessment Levels

Range and Average Benzene Concentrations Recorded	
Range of recorded weekly concentrations (µg/m^3)	<0.4 – 56.3
Average on-site concentration recorded (µg/m^3)	3.11
Average on-site concentration recorded near the soil hospital (µg/m^3)	5.29
Average on-site concentration recorded excluding the soil hospital (µg/m^3)	2.47
Average on-site concentration following closure of the soil hospital (µg/m^3)	2.00
Average concentrations recorded in off-site monitoring locations (µg/m^3)	1.71
Air Quality Assessment Levels	
UK / EU Air Quality Standard (µg/m^3)	5 (Annual average)
WHO Air Quality Guideline (µg/m^3)	0.17 – 17
Other UK Assessment Level (µg/m^3)	-
Air Quality Assessment Level (other than UK) (µg/m^3)	-
USA ATSDR minimal risk levels (µg/m^3)	9.6 (chronic)
Odour Threshold (µg/m^3)	5,000 (US EPA)[8]

Key:
Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages
<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events
-: either no standard or guidance is available for the chemical or a more suitable value is available

Benzene is required for the manufacture of a wide range of materials including plastics, foams, dyes, detergents, solvents and insecticides. Exposure to benzene is mainly through inhalation and major sources include vehicle exhaust, evaporation of petrol and petrol manufacturing. Average levels of benzene at monitoring stations in the vicinity of the soil hospital (5.29 µg/m^3) were recorded slightly above the UK Air Quality Standard (AQS) of 5 µg/m^3 as an annual average; however, average levels of benzene across the site (3.11 µg/m^3) and across the site excluding the soil hospital (2.47 µg/m^3) were below the UK AQS. This indicates that whilst benzene concentrations were occasionally in excess of the AQS at the soil hospital and area of excavation, concentrations are likely diluting in air to be beneath the AQS at the site boundary where the surrounding population are present.

[8] United States Environmental Protection Agency, Benzene
https://www.epa.gov/sites/production/files/2016-09/documents/benzene.pdf

The average benzene levels excluding the soil hospital (2.47 µg/m^3) across the site have been comparable to the WHO value of 1.7 µg/m^3 which corresponds to an estimated excess lifetime cancer risk of 1 in 100,000. It is also useful to note that benzene is present in the environment from a number of different sources and the WHO has stated that ambient (natural) air concentrations of benzene in rural and urban areas are approximately 1 µg/m^3 and 5–20 µg/m^3 respectively (depending on the type of area). Background data for three monitoring locations in London recorded average concentrations of 0.45 µg/m^3 (London Eltham, daily mean 2018), 0.56 µg/m^3 (London Bloomsbury, multi-day data 2018) and 0.87 µg/m^3 (London Marylebone, daily mean 2018)[9].

Whilst occasional peak benzene concentrations (maximum 56.3 µg/m^3, at one monitoring location during week 31) were recorded above the UK AQS, it should be noted that the standard is based on an annual average and the peak exceedance would not be expected to represent a significant increased risk to health. As over time the average concentrations are lower, it can be concluded that the health risk from the reported benzene concentrations is likely to be low.

Naphthalene

Table 3 – Recorded Naphthalene Concentrations and Air Quality Assessment Levels

Range and Average Naphthalene Concentrations Recorded	
Range of recorded weekly concentrations (µg/m^3)	<0.2 - 248.2
Average on-site concentration recorded (µg/m^3)	9.67
Average on-site concentration recorded near the soil hospital (µg/m^3)	20.42
Average on-site concentration recorded excluding the soil hospital (µg/m^3)	6.54
Average on-site concentration following closure of the soil hospital (µg/m^3)	4.58
Average concentrations recorded in off-site monitoring locations (µg/m^3)	1.16
Air Quality Assessment Levels	
UK / EU Air Quality Standard (µg/m^3)	-
WHO Air Quality Guideline (µg/m^3)	10 (Annual average)
Other UK Assessment Level (µg/m^3)	3.00 (PHE, annual)[10]
Air Quality Assessment Level (other than UK) (µg/m^3)	-
USA ATSDR minimal risk levels (µg/m^3)	3.00 (chronic)
Odour Threshold (µg/m^3)	7.5 to 420 (WHO)[11]

Key:
Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages
<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events
-: either no standard or guidance is available for the chemical or a more suitable value is available

Naphthalene is present in the environment from various sources such as vehicle exhaust, use of solvents or creosote. The main route of exposure is inhalation, especially in the vicinity of heavy traffic, petrol stations and oil refineries. Naphthalene

[9] DEFRA, UK-Air
https://uk-air.defra.gov.uk/
[10] Public Health England, Indoor Air Quality Guidelines for selected Volatile Organic Compounds (VOCs) in the UK, September 2019
[11] World Health Organisation, Guidelines for Indoor Air Quality, 2010

is used in moth repellents and has a distinctive smell. The average site-wide concentration excluding the soil hospital of 6.54 µg/m^3 is comparable to the WHO Indoor Air Quality Guideline of 10 µg/m^3 as an annual average. Average concentrations at the soil hospital (20.42 µg/m^3) are above the WHO guideline value, however some dilution is likely to have occurred, before reaching surrounding residents. Additional factors would have resulted in a reduced exposure to the surrounding population, including the changing wind direction throughout the course of the monitoring period; which would mean that the exposure of any population in up-wind areas would have decreased with the changing wind direction.

The average site-wide concentration excluding the soil hospital of 6.54 µg/m^3 is above the PHE air quality guideline and US ATSDR chronic minimal risk level (MRL) (both 3.00 µg/m^3). The detection of naphthalene at levels above both of these standards and the WHO guideline value does not indicate an immediate risk to health, as the guidelines have been set to be protective of exposures over a lifetime and therefore exceedances for part of the lifetime would not automatically result in an increased risk to health. Furthermore, a range of factors will mean that levels will have been lower beyond the site boundary.

It is noted that the site average concentrations following closure of the soil hospital (4.58 µg/m^3) are lower than the average concentration recorded for the entire monitoring period (9.67 µg/m^3). Furthermore, the concentrations recorded at off-site monitoring locations (1.16 µg/m^3) are beneath the MRL. Therefore, considering that the off-site concentrations are falling to beneath the MRL and assuming that this trend continues, the detected levels of naphthalene do not represent an immediate risk to health and the risk of any long-term health impacts is likely to be low.

Trichloroethylene

Table 4 – Recorded Trichloroethylene Concentrations and Air Quality Assessment Levels

Range and Average Trichloroethylene Concentrations Recorded	
Range of recorded weekly concentrations (µg/m^3)	<0.6 – 475.3
Average on-site concentration recorded (µg/m^3)	2.05
Average on-site concentration recorded near the soil hospital (µg/m^3)	1.97
Average on-site concentration recorded excluding the soil hospital (µg/m^3)	2.07
Average on-site concentration following closure of the soil hospital (µg/m^3)	2.08
Average concentrations recorded in off-site monitoring locations (µg/m^3)	5.13
Air Quality Assessment Levels	
UK / EU Air Quality Standard (µg/m^3)	-
WHO Air Quality Guideline (µg/m^3)	2.3 – 230
Other UK Assessment Level (µg/m^3)	0.21 – 21 (PHE)
Air Quality Assessment Level (other than UK) (µg/m^3)	Inhalation unit risk 4.8 x 10^{-6} per ug/m^3 (US EPA)
USA ATSDR minimal risk levels (µg/m^3)	2 (chronic)
Odour Threshold (µg/m^3)	-

Key:
Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages

<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events
-: either no standard or guidance is available for the chemical or a more suitable value is available

The average concentration recorded across the entire monitoring period at on-site monitoring locations was 2.05 µg/m^3, comparable to the WHO guideline value of 2.3 µg/m^3 which corresponds to an estimated excess lifetime cancer risk of 1 in 1,000,000 and the PHE guideline value of 2.1 µg/m^3 which corresponds to an estimated excess lifetime cancer risk of 1 in 100,000.

The US EPA (2011) evaluation of cancer risk based on human kidney cancer data adjusted for other cancers calculated a lifetime inhalation unit cancer risk estimate of 4.8×10^{-6} per µg/m^3. Based on the US EPA unit risk estimate lifetime exposure to the site average concentration of trichloroethylene of 2.05 µg/m^3 equates to an estimated excess lifetime cancer risk estimate of 1 in 100,000.

Comparison of the average site results against the WHO guideline value and US EPA unit risk estimate is precautionary as these values are used to assess lifetime exposure.

The site average concentration of trichloroethylene of 2.05 µg/m^3 slightly exceeds the ATSDR chronic MRL (for assessment of non-cancer endpoints) of 2 µg/m^3. Exceedance of the MRL does not necessarily mean health effects will occur. Furthermore, PHE notes that the majority of onsite trichloroethylene results were recorded beneath the limit of detection and the MRL[12].

Whilst some peak concentrations were recorded above the relevant health-based guidance values for trichloroethylene it should be noted that the values are used to assess lifetime exposure (concentrations recorded above the WHO air quality guideline (230 µg/m^3), were recorded during week 42 at Air 04, on the north-eastern site boundary (400.10 µg/m^3) and Air 19, off-site to the west (475.3 µg/m^3). Therefore, exceedances for a short period of a lifetime would not be expected to represent a significant increased risk to health.

As noted above, during week 42, two sample locations recorded elevated concentrations of trichloroethylene time points, which Atkins indicated were possibly attributable to either the on-site asphalting of roads, as well as the off-site tarmacking industry, considering that trichloroethylene is used in bitumen production.

It is noted that concentrations were locally recorded across the site and where trichloroethylene was detected at one monitoring station, it was recorded beneath the limit of detection at the nearest adjacent monitoring station, indicating a high level of dispersion and dilution. Furthermore, trichloroethylene was not consistently recorded at certain monitoring stations, indicating that if the nearby population were exposed, this would have been short lived. Taking consideration of the local detections of this

[12] 53 of 1535 on-site monitoring results for trichloroethylene were recorded above the limit of detection. Note that the limit of detection is beneath the ATSDR MRL

compound and the high level of dispersion and dilution in air, the health risk is likely to be low.

4-Isopropyltoluene

Table 5 – Recorded 4-Isopropyltoluene Concentrations and Air Quality Assessment Levels

Range and Average 4-Isopropyltoluene Concentrations Recorded	
Range of recorded weekly concentrations (µg/m^3)	<0.6 – 137.6
Average on-site concentration recorded (µg/m^3)	1.5
Average on-site concentration recorded near the soil hospital (µg/m^3)	1.4
Average on-site concentration recorded excluding the soil hospital (µg/m^3)	1.52
Average on-site concentration following closure of the soil hospital (µg/m^3)	1.35
Average concentrations recorded in off-site monitoring locations (µg/m^3)	<1.36
Air Quality Assessment Levels	
UK / EU Air Quality Standard (µg/m^3)	-
WHO Air Quality Guideline (µg/m^3)	-
Other UK Assessment Level (µg/m^3)	-
Air Quality Assessment Level (other than UK) (µg/m^3)	2 (AGOF)[13]
USA ATSDR minimal risk levels (µg/m^3)	-
Odour Threshold (µg/m^3)	-

Key:
Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages
<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events
-: either no standard or guidance is available for the chemical or a more suitable value is available

4-isopropyltoluene (also known as ρ-cymene) is an ingredient of essential oils and is noted for its sweet and characteristic odour[14]; although there is no identified odour threshold, ρ-Cymene is a very versatile chemical which can be used in a wide variety of applications including polishes and sanitation goods such as soaps and detergents. Its use as a fragrance agent in commercial and consumer products may result in its release into the environment. Concentrations of this chemical were all recorded beneath laboratory limits of detection, with the exception of the following periods:

- Between the 3rd and 14th August 2018, during which it was recorded above limits of detection on seven of ten monitoring locations between 1 and 138 µg/m^3 (average concentration during this period of 22 µg/m^3 on all monitoring equipment);
- Between 16th and 23rd October 2018, during which it was recorded above limits of detection on one of twenty-one monitoring locations (recorded concentration of 4.3 µg/m^3 at monitoring station Air 3);
- Between 20th and 27th June 2019, during which it was recorded above limits of detection on one of twenty-six monitoring locations (recorded concentration of 3.5 µg/m^3 at monitoring station Air 6); and

[13] AGÖF, The German Association of Ecological Research Institutes, Guidance Values for Volatile Organic Compounds in Air https://www.agoef.de/orientierungswerte/agoef-voc-guidance-values.html
[14] p-Cymene datasheet https://pubchem.ncbi.nlm.nih.gov/compound/7463#section=Top

- Between 19th and 26th September 2019, during which it was recorded above limits of detection on one of twenty-six monitoring locations (recorded concentration of 3.2 µg/m^3 at monitoring station Air 21).

Some concentrations during these periods were recorded in excess of the AGÖF (The German Association of Ecological Research Institutes) guidance value of 2 µg/m^3; however, the average concentration at the site boundary was 1.52 µg/m^3 which is beneath the AGÖF guidance value and comparable to levels collected from 15 micro environments in Birmingham[15] (homes, offices, restaurants, cinemas, libraries, buses, cars, etc) that contained average p-cymene concentrations ranging from 0.3 to 4.9 µg/m^3. Overall health impacts are considered to be minimal, p-cymene may have been a constituent of the odour suppressant used on site noting the short period and the fact that there is no ongoing exposure, with concentrations recorded beneath the laboratory detection limit and health standard during all other monitoring periods.

Trimethylbenzenes

Table 6 – Recorded Trimethylbenzene Concentrations and Air Quality Assessment Levels

Range and Average Trimethylbenzene Concentrations Recorded	
Range of recorded weekly concentrations (µg/m^3)	<1.6 - 70.0
Average on-site concentration recorded (µg/m^3)	2.96
Average on-site concentration recorded near the soil hospital (µg/m^3)	3.79
Average on-site concentration recorded excluding the soil hospital (µg/m^3)	2.71
Average on-site concentration following closure of the soil hospital (µg/m^3)	2.75
Average concentrations recorded in off-site monitoring locations (µg/m^3)	2.69
Air Quality Assessment Levels	
UK / EU Air Quality Standard (µg/m^3)	-
WHO Air Quality Guideline (µg/m^3)	-
Other UK Assessment Level (µg/m^3)	1,250 (EAL annual limit)[16]
Air Quality Assessment Level (other than UK) (µg/m^3)	60 (US EPA RfC)[17]
USA ATSDR minimal risk levels (µg/m^3)	-
Odour Threshold (µg/m^3)	590

Key:
Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages
*: (Sum of 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene isomer concentrations reported)
<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events
-: either no standard or guidance is available for the chemical or a more suitable value is available

Trimethylbenzenes are produced during petroleum refining and during the production of certain aromatic hydrocarbons. As the vast majority of these hydrocarbons are a component of petrol, vehicle emissions are expected to be the main human source in the vicinity of the site.

[15] https://pubchem.ncbi.nlm.nih.gov/compound/7463
[16] Environmental Assessment Levels
https://www.gov.uk/guidance/air-emissions-risk-assessment-for-your-environmental-permit#environmental-standards-for-air-emissions
[17] United Stated Environmental Protection Agency, Trimethylbenzene
https://cfpub.epa.gov/ncea/iris2/chemicalLanding.cfm?substance_nmbr=1037

Concentrations of trimethylbenzenes were generally recorded beneath or close to the limit of detection throughout the monitoring period (average recorded concentration 2.96 µg/m^3), and therefore below the United States Environmental Protection Agency reference concentration (60 µg/m^3). One concentration was recorded in excess of the reference concentration; recorded concentration 70 µg/m^3, at location Air 06 between 20th and 26th June 2019.

Considering the short period in which this concentration was recorded in excess of the reference concentration and that the site average was recorded beneath the assessment criteria during all other monitoring periods, the health risk is considered to be low.

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Chemicals Recorded Beneath Assessment Criteria

Table 7 shows a summary of the identified VOC concentrations from the monitoring results, compared with available health-based standards or assessment levels. All chemicals presented in Table 7 have been recorded beneath their respective assessment criteria. For completeness, calculated average concentrations based on different locations are presented in Appendix 2.

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Table 7 – Summary of identified chemicals for which peak or average concentrations were recorded below air quality assessment levels

Chemical	Range of recorded weekly concentrations (µg/m^3)	Average on-site concentration recorded (µg/m^3)	UK / EU Air Quality Standard (µg/m^3)	WHO Air Quality Guideline (µg/m^3)	Other UK Assessment Level (µg/m^3)	Air Quality Assessment Level (other than UK) (µg/m^3)	USA ATSDR minimal risk levels (µg/m^3)	Odour Threshold (µg/m^3)
Toluene	<0.6 - 132.8	3.73	-	260 (Weekly average)	2,300 (PHE, daily average)	250 (Portugal, Annual)[18]	3,800 (chronic)	1,000 (WHO)[19]
Styrene	<0.5 – 12.7	1.17	-	260 (Weekly average)	850 (PHE, annual)	220 (Japan, Annual)[20]	1,000 (chronic)	70 (WHO)
Xylene (o, m, p)	<1.3 - 80.0	5.09	-	-	100 (PHE, annual)	100 (Health Canada, Annual)[21]	217 (chronic)	4,776 (US EPA)[22]
Ethylbenzene	<0.4 – 67.9	1.35	-	-	4,410 (EAL annual limit)	200 (Germany, RWI)[23]	260 (chronic)	738
Propanone / Acetone	<2.8 – 13.7	5.76	-	-	18,100 (EAL annual limit)	161 (AGOF)[13]	30,457 (chronic)	47,500 – 1,613,900 (PubChem)[24]
Diethyl ether	<0.7 - 110.3	1.64	-	-	12,300 (EAL annual limit)	-	-	990 – 3,000 (PubChem)[25]
Carbon disulphide	<0.3 - 1.4	0.59	-	100 (Daily average)	64 (EAL annual limit)	-	921 (chronic)	20 (WHO, 20minute period)
1,2-Dichlorobenzene	<0.7 - 3.5	1.46	-	-	153,000 (WEL)[26]	600 (Tolerable Concentration in Air)[27]	-	1,800 – 300,000 (PubChem)[28]
Dichloromethane	<0.4 - 7.0	0.84	-	450 (Weekly average)	-	-	-	530,000 – 2,120,000 (WHO)

[18] Portuguese Ministries of Environment, Spatial Planning and Energy, Health and Solidarity, Employment and Social Security, 2013
[19] World Health Organisation, Air Quality Guidelines for Europe, Second Edition 2000
[20] Japanese Ministry of Health, Labour and Welfare, 2017
[21] Health Canada, https://www.canada.ca/en/health-canada.html, 2018
[22] United States Environmental Protection Agency
https://www.epa.gov/sites/production/files/2016-09/documents/xylenes.pdf
[23] German Federal Environment Agency UBA, 2016. RWI represents the concentration of a substance in indoor air for which, when considered individually, there is no evidence at present that even life-long exposure is expected to bear any adverse health impacts.
[24] Acetone Summary Pubchem
https://pubchem.ncbi.nlm.nih.gov/compound/acetone#section=Top
[25] Ether Summary Pubchem
https://pubchem.ncbi.nlm.nih.gov/compound/diethyl_ether#section=Top
[26] EH40 Workplace Exposure Limit (8 hour)
[27] Vermeire et al (1991), Voorstel voor de humaan-toxicologische onderbouwing van C-(toetsings)waarden.
[28] o-Dichlorobenzene Summary Pubchem
https://pubchem.ncbi.nlm.nih.gov/compound/1_2-dichlorobenzene#section=Top

Chemical	Range of recorded weekly concentrations (µg/m^3)	Average on-site concentration recorded (µg/m^3)	UK / EU Air Quality Standard (µg/m^3)	WHO Air Quality Guideline (µg/m^3)	Other UK Assessment Level (µg/m^3)	Air Quality Assessment Level (other than UK) (µg/m^3)	USA ATSDR minimal risk levels (µg/m^3)	Odour Threshold (µg/m^3)
trans-1,2-Dichloroethene	<0.5 - 44.6	1.02	-	-	806,000 (WEL)		782 (intermediate)	335.7 (PubChem)[29]
2-Butanone / Methyl ethyl ketone	<1 - 17.0	7.15	-	-	600,000 (WEL)	1,000 (US EPA (RfC)[30]	2,908 (acute)	21,116 (US EPA)
Tetrachloromethane / Carbon tetrachloride	<0.7 - 3.6	1.50	-	-	6,400 (WEL)	-	186 (chronic)	62,049 (US ATSDR)
Methyl methacrylate	<1 - 4.7	1.98	-	-	208,000 (WEL)	200 (WHO tolerable concentration)	-	-
Tetrachloroethene / Tetrachloroethylene	<0.8 - 3.9	1.63	-	250 (Annual average)	40 (PHE, daily)	-	40 (chronic)	6,689 (US EPA) 8,000 (WHO)
Isopropylbenzene / Cumene	<0.6 - 6.5	1.18	-	-	125,000 (WEL)	90 – 400 (WHO inhalation guidance values)[31]	-	430 (WHO)
Methyl-tertiary-butyl ether	<0.4 – 6.2	0.89	-	-	183,500 (WEL)		2,489 (chronic)	320 (US ATSDR)

Key:
Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages
<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events
-: either no standard or guidance is available for the chemical or a more suitable value is available

[29] Trans-1,2-Dichloroethene summary
https://pubchem.ncbi.nlm.nih.gov/compound/trans-1%2C2-dichloroethylene#section=Ionization-Potential
[30] 2-Butanone US EPA Reference Concentration
https://www.epa.gov/sites/production/files/2016-09/documents/methyl-ethyl-ketone.pdf
[31] WHO Concise International Chemical Assessment Document 18, Cumene
https://www.who.int/ipcs/publications/cicad/cicad18_rev_1.pdf

The majority of chemicals identified in Table 7 have appropriate health-based guidelines, which are protective of health for the surrounding population. For these compounds, as the recorded concentrations are beneath these assessment criteria and often beneath their limits of detection it can be concluded that the health risks posed by these chemicals are very low or negligible.

Chemicals with no Assessment Criteria

Table 8 shows a summary of the identified VOC concentrations from the monitoring results which do not have an available health-based standards or assessment levels. For completeness, calculated average concentrations based on different locations are presented in Appendix 2.

Table 8 – Summary of identified chemicals which do not have available air quality assessment levels

Chemical	Range of recorded weekly concentrations (µg/m^3)	Average on-site concentration recorded (µg/m^3)	Other UK Assessment Level (µg/m^3)	Odour Threshold (µg/m^3)
sec-Butylbenzene	<0.6 – 6.2	1.42	-	47
1-Chlorobutane	<0.4 - 2.2	0.90	-	3,335.2 (PubChem)[32]
1,1-Dichloropropene	<0.5 - 3.1	1.09	-	-
n-Propylbenzene	<0.6 - 8.7	1.20	-	-
Bromoform	<1.2 - 6.1	2.50	-	-
tert-Butylbenzene	<0.6 - 8.1	1.35	-	-
1,3-Dichlorobenzene	<0.7 - 3.5	1.47	-	-
n-Butylbenzene	<0.6 - 3.20	1.35	-	-
2-Nitropropane	<0.8 - 4.2	1.78	18,000 (WEL)	255,000 (US EPA)
2-Hexanone	<1 - 7.1	3.00	21,000 (WEL)	310 (ATSDR)
1,1-Dichloroethane	<0.5 - <2.3	0.99	399,193 (WEL)	486,000 (WHO)[33]
1,3-Dichloropropane	<0.5 – 2.7	1.10	-	-
trans-1,4-Dichloro-2-butene	<1.2 – 5.9	2.48	-	-

Key:
Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages
<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events
-: either no standard or guidance is available for the chemical or a more suitable value is available

As detailed in Table 8, there are no available air quality guidelines for certain identified compounds. Concentrations of each of these were typically recorded less than, or marginally exceeding their respective limit of detection. Whilst no air quality guidelines are available for these compounds, considering the short periods these compounds were typically present and the low concentrations recorded, close to or beneath the limit of detection, the associated health risks are considered to be minimal.

[32] 1-Chlorobutane Summary https://pubchem.ncbi.nlm.nih.gov/compound/1-Chlorobutane#section=Heat-of-Vaporization

[33] World Health Organisation, 2003, 1,1-Dichloroethane in Drinking-water

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Total Volatile Organic Compounds

Five monitoring stations have measured concentrations of total volatile organic compounds (TVOC) since January 2017, which were reported by Atkins to have been installed for the protection of on-site workers. There are difficulties with the assessment of readings for total volatile organic compounds, as the total value includes a range of chemicals, all of which have varying levels of toxicity. The measurement of TVOC is in parts per million (ppm), as opposed to micrograms per cubic meter (µg/m^3). PPM records the frequency of VOCs present in air; however, given that there is a range of VOCs included in this measurement, it is hard to convert ppm to µg/m^3, given the different weight of each VOC. Therefore, there are difficulties with the comparison of these values to the air quality assessment levels presented in Table 1.

A graphical representation of TVOC concentrations has been presented by Atkins, which identifies concentrations to have typically been recorded between 0 and 2 ppm, with short term peaks typically recorded between 3 and 12 ppm (one peak of 67 ppm was recorded). From 10th September to 23rd December 2019, Atkins reported that concentrations at all five locations did not exceed 0.1 ppm. Furthermore, previously presented eight hour average concentrations for monitoring data from 2018 and are typically below 1 ppm.

PHE have applied a precautionary value of 1.5 ppm to represent a potential hazard to health for sub-chronic inhalation exposure[34]. Graphical concentrations are generally observed to fall at or beneath this precautionary value and where there are peaks in concentrations of total volatile organic compounds, these are short lived and unlikely to be representative of long-term and chronic exposure. Furthermore, it is noted that the monitoring stations are positioned on the site boundary, and TVOC levels in air would likely further dilute before reaching the surrounding population. Based on the above, it is considered that the human health risks are minimal.

Further to the above, laboratory analysis for total petroleum hydrocarbons (TPH) has been undertaken at the 26 Tenax monitoring locations and presented to PHE. The analysis reports total concentrations of short and medium length hydrocarbons (those which are likely to be more volatile and present in air). Unlike TVOC, the results for TPH analysis are presented as µg/m^3; however, similarly to TVOC the results include a range of compounds of varying levels of toxicity and it is therefore difficult to compare these results to air quality standards, which are based on an individual compound and their specific characteristics and toxicity.

TPH monitoring results represent the sum of total VOC and SVOCs. Some of these individual compounds (such as benzene and trichloroethylene) have been individually identified and compared against their respective air quality standard. However, for a conservative assessment, the TPH monitoring results have been compared against

[34] Public Health England, Chemical Hazards and Poisons Report, September 2011, Issue 20

reference concentrations. This is the concentration at which adverse health effects, excluding carcinogenicity, would be unlikely to occur, taking account of continuous exposure over a lifetime. These results have been presented in Table 9 below.

Table 9 – Recorded Total Petroleum Hydrocarbon Concentrations and Reference Concentrations

Total Petroleum Hydrocarbon Band	Range of concentration recorded ($\mu g/m^3$)	Average on-site concentration recorded ($\mu g/m^3$)	Reference concentration ($\mu g/m^3$)[35]
Aliphatic $C_{>5} – C_8$	<2.0 – 732	6.57	18,400
Aliphatic $C_{>8} – C_{16}$	<2.0 – 1,674	35.84	1,000
Aromatic $C_{>5} – C_8$	<2.0 – 231	5.72	400
Aromatic $C_{>8} – C_{16}$	<2.0 – 3,340	40.16	200

Review of the monitoring data indicates that maximum concentrations of total petroleum hydrocarbons in the aliphatic $C_{>8-16}$ and aromatic $C_{>8-16}$ bands have been recorded in excess of their respective reference concentrations. Of 1535 individual monitoring results, the reference concentration for aliphatic $C_{>8-16}$ bands was exceeded on 9 occasions and the reference concentration for aromatic $C_{>8-16}$ bands was exceeded on 44 occasions. However, average onsite concentrations of all TPH bands are below their respective reference concentration.

As the reference concentrations are designed to be protective over a lifetime, short term exceedances where the average is below the reference concentration, are unlikely to result in a risk to health. As the average concentrations recorded are beneath the reference concentration and it can therefore be concluded that the health risk from TPH concentrations recorded on-site is low.

[35] Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG) (1997). Development of Fraction Specific Reference Doses (RfDs) and Reference Concentrations (RfCs) for Total Petroleum Hydrocarbons (TPH).

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Conclusions

The data provided to PHE by Ealing Council has been compared to available health based air quality guidelines and standards or assessment levels. Where the concentrations in air are shown to be lower than appropriate health based standards or guidelines, it may be assessed that the risk to health is minimal. On the basis of the available monitoring data, the majority of the identified chemicals were lower than the relevant air quality guidelines or standards, with the exception of benzene, trichloroethylene, trimethylbenzenes and 4-isopropyltoluene, which were intermittently above the guideline values whilst naphthalene levels were regularly above the guideline values.

The exceedances for all of these compounds with the exception of naphthalene have been for shorter periods compared with the health based guidelines which are based on annual average concentrations. However, these air quality guidelines are set to be protective over a lifetime; therefore, exceedances for part of the lifetime would not automatically result in an increased risk to health. The exceedances for all compounds have also remained below levels likely to cause acute or short term health effects.

Furthermore, it should be noted that monitoring stations are positioned on the site boundary and the concentrations of the compounds in air will have diluted further before reaching the surrounding population, reducing the potential risk. Additional factors would have resulted in a reduced exposure to the surrounding population, including the changing wind direction throughout the course of the monitoring period; which would mean that the exposure of any population in up-wind areas would have decreased with the changing wind direction.

The results for the air quality monitoring are considered unlikely to pose a direct toxicological risk to the health of the nearby population. It is noted that there is a continued decrease in concentrations following closure of the soil treatment hospital, however PHE recommends that air quality monitoring is continued at the site in case of further construction or assessment activity on the site or in close proximity (i.e. possible remediation works to be undertaken by National Grid on land adjacent to the Southall Waterside development). It is recommended that mitigation measures and monitoring are continued, so that any potential health risk can be minimised and kept under review, in light of any further works on and in proximity to the site.

It is important to make a distinction between concerns about odour and any toxicological effect from exposure to airborne chemicals. The human nose is very sensitive to odours, and substances that are perceived as odorous are commonly present at levels below which there is a direct toxicological effect. Odours can cause nuisance amongst the population, possibly leading to stress and anxiety. Some people may experience symptoms such as nausea, headaches or dizziness as a reaction to odours even when the substances that cause those smells are themselves not harmful to health.

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The monitoring data has identified that some chemicals have been recorded in excess of odour thresholds and that the surrounding population may have been subject to some odours as part of the ongoing construction works.

PHE recommends that measures continue to be taken by Ealing Council / Property Developer to reduce off-site odours from the construction site, as it is acknowledged that odours can affect an individual's wellbeing.

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Appendix 1: Limitations

Based on the monitoring data presented, Public Health England would note the following limitations to the risk assessment:

- PHE have not included an assessment of particulate matter associated with the development works. The assessment has only considered a review of volatile organic compound data, as the reported health concerns were focused on odours. Ealing Council has the responsibility as the local planning authority for overseeing and regulating particulate matter emissions in relation to the development.
- Detailed monitoring data has only been provided for a 81 week period. Laboratory analysis was not consistently undertaken at all monitoring locations during this period (i.e. 81 week monitoring data is not available for all locations). Some air quality standards are based on annual averages and as such, factors that may impact air quality through the course of the year (e.g. different site working practices, different weather conditions etc) would not have been picked up in the results.
- Monitoring periods have not been consistent across the twenty-seven sampling weeks, with periods ranging between 140 hours and 260 hours. It is considered that monitoring periods should have been kept consistent for result replicability.
- There are different techniques for air quality monitoring, each of which has advantages and disadvantages. Passive sampling has been undertaken, which has limitations in that the results may not be reflective of 'shorter-term' concentrations (i.e. during site operational hours), which would allow appropriate comparison against air quality standards for different time periods. The total volatile organic compound monitoring which was commenced in January 2017, includes 'shorter-term' values of chemicals in air; however, this monitoring technique does not detail the exact chemical recorded and as such there are difficulties in undertaking a risk assessment of this data.
- PHE have not been presented with full details on past land use for the site which would indicate the likely chemicals present on site and inform the conceptual site model. As such, PHE are unable to comment on the appropriateness of the air quality sampling undertaken; however, note that the VOC and SVOC tested are broadly consistent with the chemicals identified elsewhere on former gas works.
- It is understood that no air quality monitoring was undertaken to provide a baseline prior to construction starting. Therefore it is difficult to scientifically determine whether the ongoing development has impacted air quality. Ealing Council have ambient air quality monitoring stations as part of their statutory role; although these do not monitor volatile organic compounds[36].
- The monitoring data for total volatile organic compounds has only been provided in graphical form. Further assessment of risk could be undertaken if

[36] https://www.ealing.gov.uk/downloads/download/4240/air_quality_action_plan_aqap

concentrations were provided for each monitoring location over the time period; including comparisons against recorded diffusion tube concentrations.

- PHE have only considered air quality based on the data provided to them. It is considered that both the Environment Agency and Ealing Council would have reviewed information on potential soil and groundwater pollution associated with the planning permission for the development.

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Appendix 2: Average concentrations recorded at different site locations

Table 10 – Average concentrations at specified monitoring locations

Chemical	Range of recorded weekly concentrations (µg/m^3)	Average on-site concentration recorded (µg/m^3)	Average on-site concentration recorded near the soil hospital (µg/m^3)	Average on-site concentration recorded excluding the soil hospital (µg/m^3)	Average on-site concentration following closure of the soil hospital (µg/m^3)	Average concentrations recorded in off-site monitoring locations (µg/m^3)
Benzene	<0.4 – 56.3	3.11	5.29	2.47	2.00	1.71
Naphthalene	<0.2 - 248.2	9.67	20.42	6.54	4.58	1.16
Toluene	<0.6 - 132.8	3.73	5.98	3.07	2.85	2.85
Styrene	<0.5 – 12.7	1.17	1.31	1.12	1.14	1.12
Xylene (o, m, p)	<1.3 - 80.0	5.09	8.02	4.23	4.08	4.17
Trimethylbenzenes	<1.6 - 70.0	2.96	3.79	2.71	2.75	2.69
Trichloroethylene	<0.6 – 475.3	2.05	1.97	2.07	2.08	5.13
Ethylbenzene	<0.4 – 67.9	1.35	1.80	1.20	1.23	1.17
sec-Butylbenzene	<0.6 – 6.2	1.40	1.43	1.39	1.38	1.38
4-Isopropyltoluene	<0.6 – 137.6	1.50	1.40	1.52	1.35	<1.36
Propanone / Acetone	<2.8 – 13.7	5.76	<5.76	5.77	<5.8	<5.86
Diethyl ether	<0.7 - 110.3	1.64	1.52	1.67	1.58	1.50
Carbon disulphide	<0.3 - 1.4	0.59	0.59	0.59	<0.59	<0.6
1,2-Dichlorobenzene	<0.7 - 3.5	1.46	<1.46	1.46	<1.47	<1.48
Dichloromethane	<0.4 - 7.0	0.84	<0.83	0.84	<0.84	<0.85
trans-1,2-Dichloroethene	<0.5 - 44.6	1.02	1.00	1.02	1.01	1.31
2-Butanone / Methyl ethyl ketone	<1 - 17.0	7.15	<7.14	7.15	<7.20	<7.27
1-Chlorobutane	<0.4 - 2.2	0.89	<0.89	0.89	<0.90	<0.91
1,1-Dichloropropene	<0.5 - 3.1	1.08	<1.08	1.08	<1.09	<1.10
Tetrachloromethane / Carbon tetrachloride	<0.7 - 3.6	1.50	1.50	1.50	1.52	1.54
2-Nitropropane	<0.8 - 4.2	1.77	1.77	<1.77	<1.78	<1.8
Methyl methacrylate	<1 - 4.7	1.98	<1.98	1.98	<2.0	<2.02
2-Hexanone	<1.4 - 7.1	2.98	2.98	2.97	<3.00	<3.03
Tetrachloroethene / Tetrachloroethylene	<0.8 - 3.9	1.63	1.63	<1.63	<1.64	1.66
Bromoform	<1.2 - 6.1	2.48	<2.47	2.48	<2.5	<2.53
Isopropylbenzene / Cumene	<0.6 - 6.5	1.18	1.18	1.19	1.20	<1.2
n-Propylbenzene	<0.6 - 8.7	1.19	1.18	1.19	1.20	<1.21
tert-Butylbenzene	<0.6 - 8.1	1.34	1.34	1.34	1.35	<1.36
1,3-Dichlorobenzene	<0.7 - 3.5	1.46	<1.46	1.46	<1.47	<1.48
n-Butylbenzene	<0.6 - 3.20	1.34	1.35	<1.33	<1.34	<1.36

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Chemical	Range of recorded weekly concentrations (µg/m^3)	Average on-site concentration recorded (µg/m^3)	Average on-site concentration recorded near the soil hospital (µg/m^3)	Average on-site concentration recorded excluding the soil hospital (µg/m^3)	Average on-site concentration following closure of the soil hospital (µg/m^3)	Average concentrations recorded in off-site monitoring locations (µg/m^3)
Methyl-tertiary-butyl ether	<0.4 – 6.2	0.89	<0.88	0.89	0.90	0.90
1,1-Dichloroethane	<0.5 - <2.3	0.98	<0.98	0.98	0.99	<1.0
1,3-Dichloropropane	<0.5 – 2.7	1.09	<1.09	1.10	<1.11	<1.12
trans-1,4-Dichloro-2-butene	<1.2 – 5.9	2.46	<2.46	2.46	2.48	<2.51

Key:

Refer to Table 1 for monitoring locations and monitoring periods for concentration ranges and averages

*: (Sum of 1,2,4-trimethylbenzene and 1,3,5-trimethylbenzene isomer concentrations reported).

<: Chemical is recorded beneath laboratory detection limits. This is the lowest concentration that the laboratory can detect the presence of a chemical. This will vary between each chemical and the same chemical during different sampling events.